Polarization Profile Issue for the Fixed Target Experiment

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Beam Polarization Profile Issue for the Fixed Target

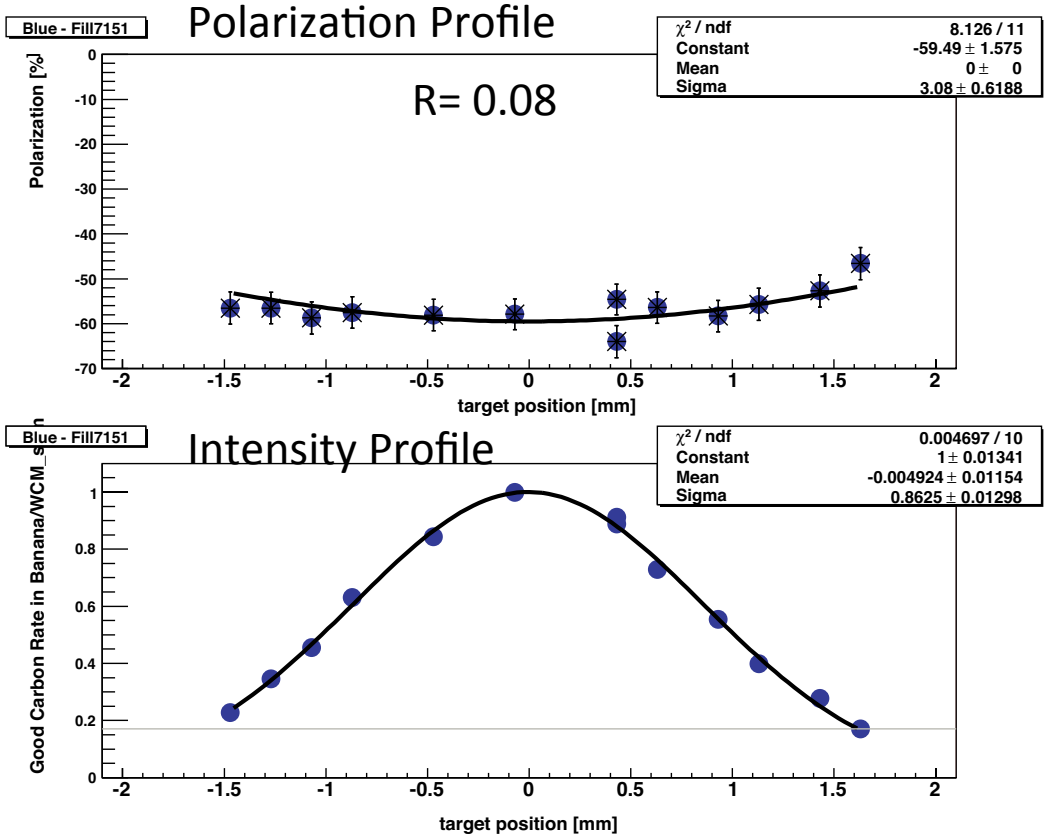


Fig. Polarization and intensity profile observed in Run5. Polarization profile was measured in a few % statistical error by taking data for longer time towards the edge.

- The fixed target experiment is designed to use the edge of the beam intensity profile in order to avoid immediate beam loss.
- It is known that the beam polarization has also profile and the polarization is lower and lower as a function of the distance from the beam center.
- This is a critical issue for the fixed target experiment using the polarized beam.

Run15 Fixed Target Beam Condition

From Run15 fixed target pilot run

- β^* of the beam = 10m
- The transverse beam size is ~300μm at the location of fixed target (2m away from IP)
- The fixed target experiment was carried out at 7mm away from the target.
- This corresponds to 23σ of the beam intensity profile.

Observed Polarization Profiles from Past Runs

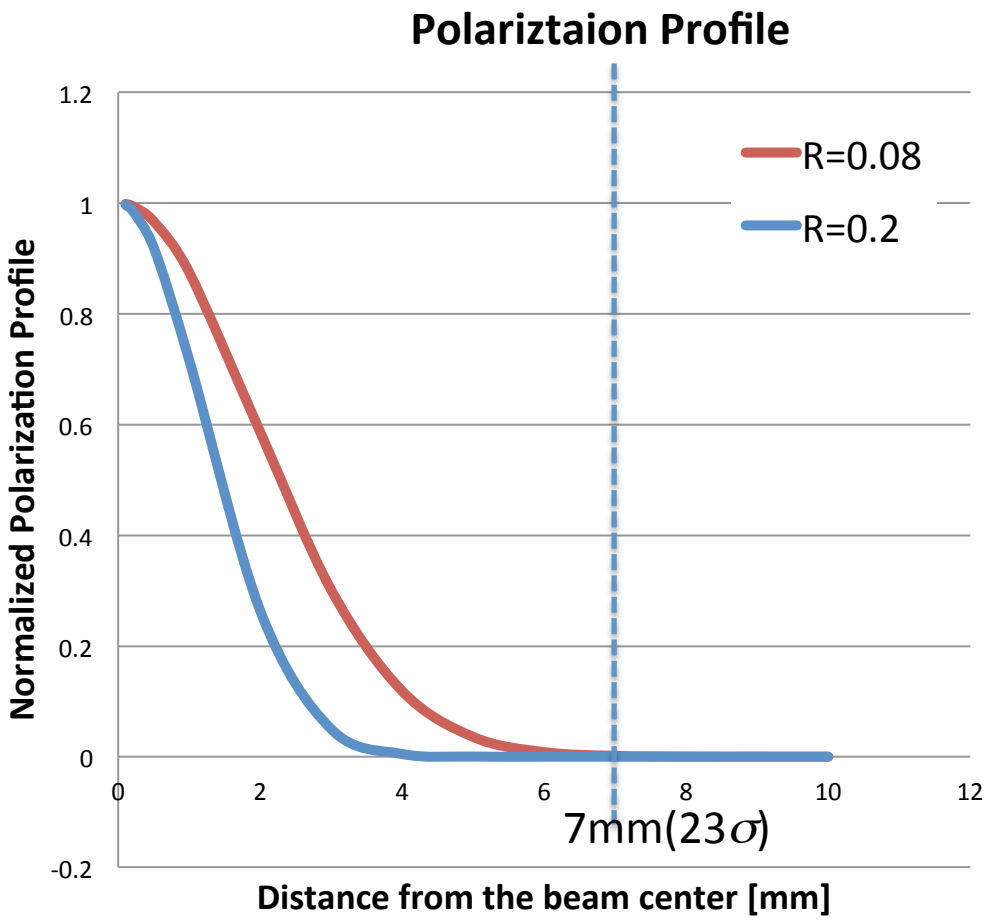
data source : cnipol webpage

$$R = \left(\frac{\sigma_I}{\sigma_P} \right)^2$$

	100 GeV		250 GeV	
	Horizontal	Vertical	Horizontal	Vertical
Run 9	0.073	0.075	0.37	
	0.056	0.117	0.32	0.39
Run12	0.097	0.122	0.17	0.21
	0.091	0.11	0.14	0.07
	0.24	0.088	0.12	0.15
	0.10	0.20	0.15	0.06
Run13			0.17	0.21
			0.14	0.07
			0.12	0.15
			0.15	0.06

R values are larger at 250 GeV which indicates smaller σ_p from smaller σ_I than 100GeV. Let's wildly assume R=0.2 and R=0.08 as typical polarization profile for 250GeV and 100GeV, respectively.

Expected Polarization at 7mm



Normalized Polarization Profile

$$\frac{P}{P_{Max}} = \left(\frac{I}{I_{Max}}\right)^{R}$$

where

$$\frac{I}{I_{Max}} = \exp\left(-\frac{2x^2}{\sigma_I}\right)$$

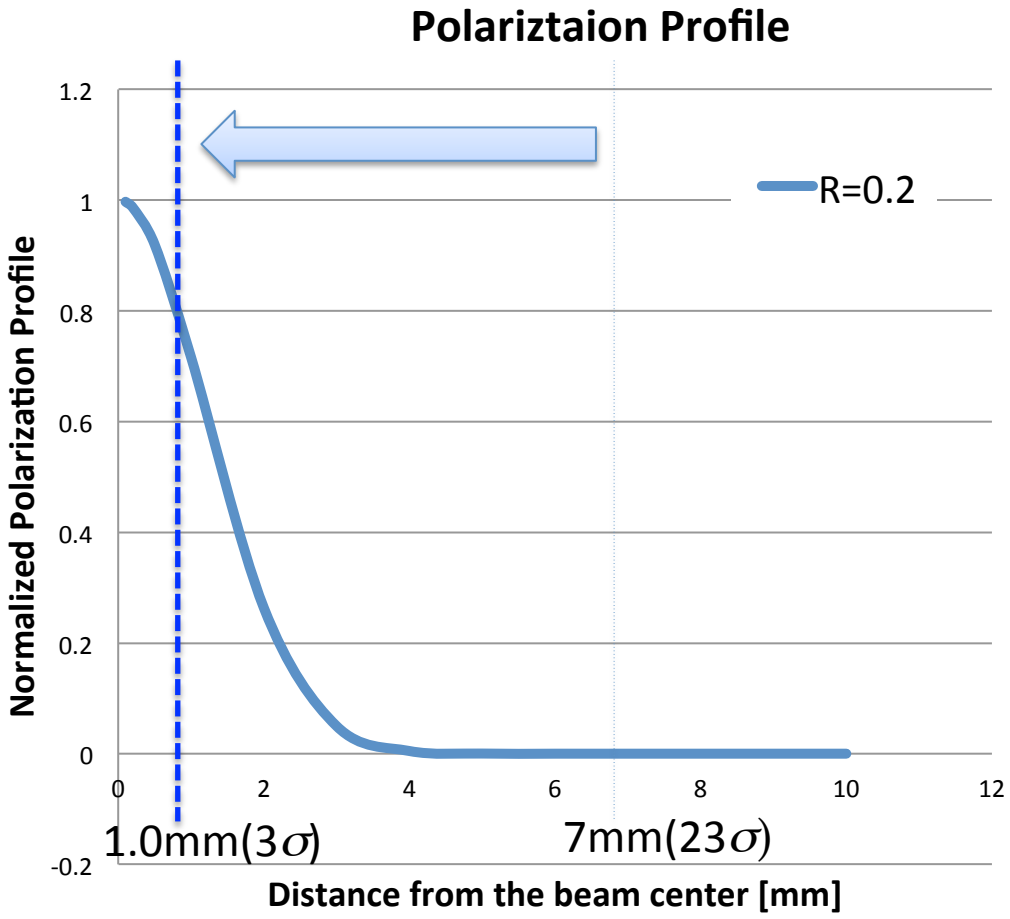
$$\sigma_I = 300\,\mu m$$

Expected polarizations were calculated for 0.08 and 0.2 as typical profile for 100GeV and 250GeV. Nevertheless regardless of beam energy, the polarization is nearly zero at 7mm away from the center.

Interim Summary

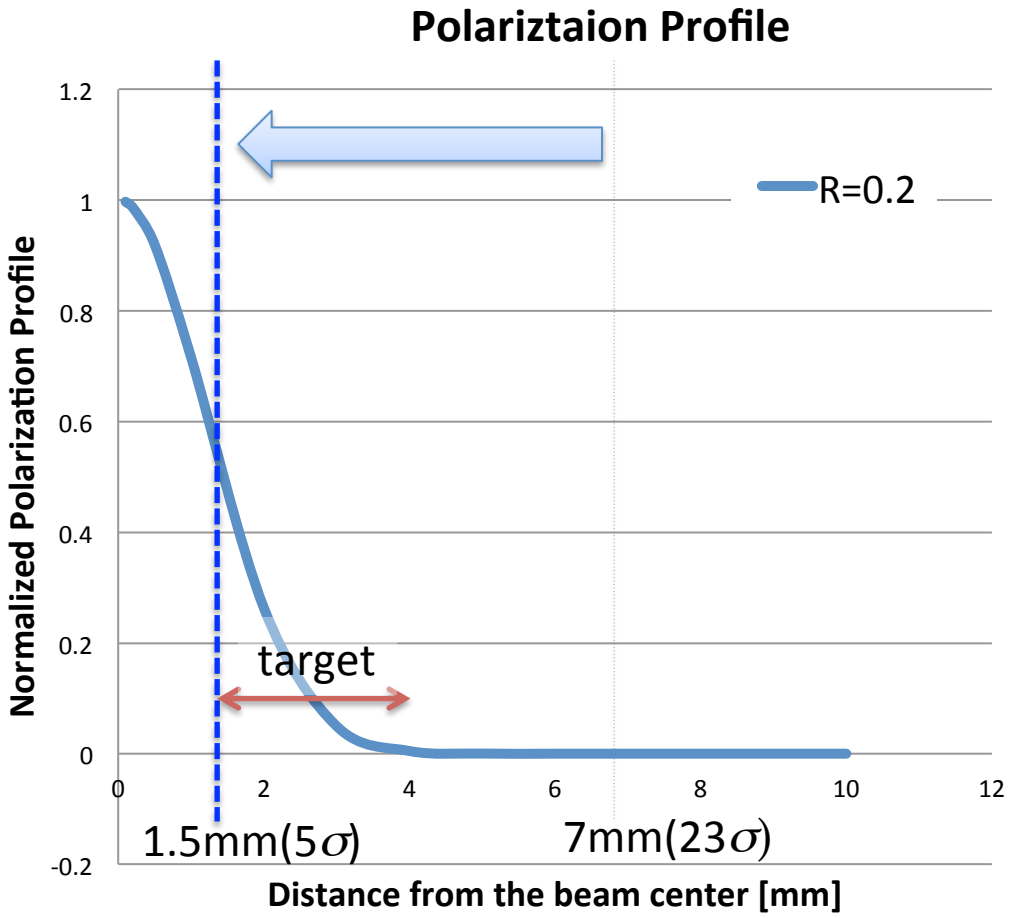
- It is unfeasible to expect decent polarization for the 250GeV proton beam under the existing fixed target operating condition, i.e. distance between the beam center and the target of about 7mm (23σ).
- This is an unique issue for the polarized proton beam and not the case for unpolarized beam.

Any get around solutions?



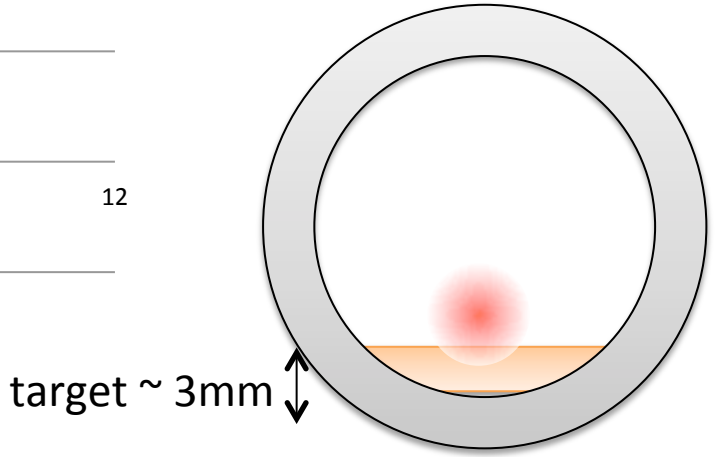
The only way to execute fixed target under decent polarization is to shift the beam center closer to the target with reduced beam intensity. The required distance will be < 3σ, where polarization is expected to be 80% of the beam center. However the beam intensity is 1% at 3σ of the center here and therefore the beam will be lost right away. An order of magnitude thinner target won't help.

Any get around solutions?

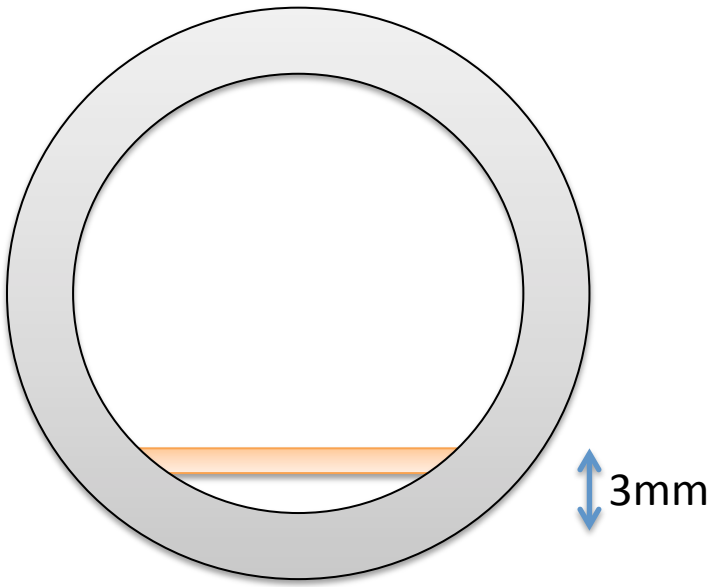


If the beam is away from the target by 5σ, the beam intensity is 7 order of magnitude lower than the where polarization is expected to be ½ of the beam center.

However, the polarization changes drastically within the target area. This rapid change introduce trouble to evaluate the polarization.



Wire Target



From target to the beam pipe is 3mm. This is additional 10σ in the beam intensity profile.

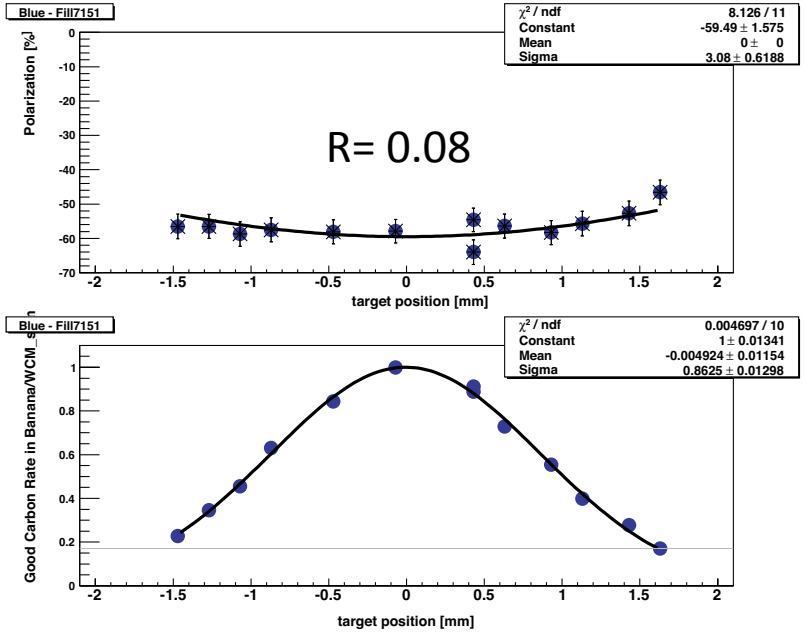
- In order to avoid covering steep polarization profile, the wire/strip target is to be considered.
- It is still require to shift the beam to the target less than 5σ. The feasibility is to be studied for
  - Beam loss and radiation interlock limit
  - Radiation to detectors by the beam scraping backgrounds.
  - More irreducible beam scraping background fraction in RHICf.
  - Engineering issue; support, heat loads, etc.
  - Systematic error of the polarization at the target position.

Summary

- The polarization profile is the critical issue for the fixed target measurement.
- Shorten the distance between the beam center to the target within 5σ or less, no polarization is expected.
- Will seek for the feasibility for the wire/strip target.

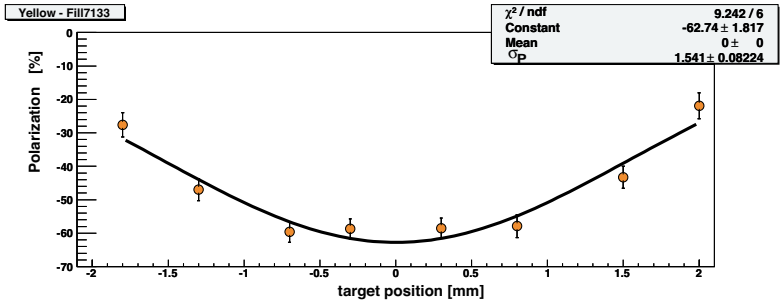
BACKUP SLIDES

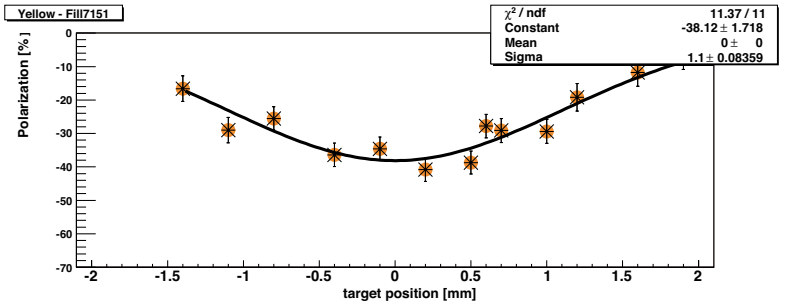
Dedicated Polarization Measurements in Run5 (Blue)

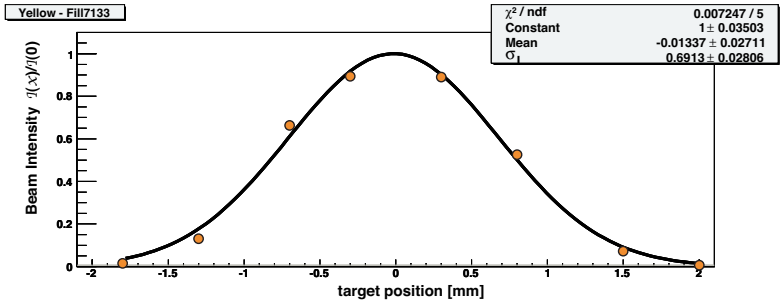


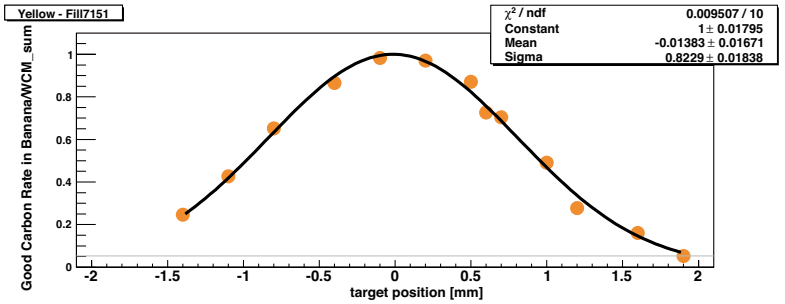
- Spent longer data taking time towards away from the beam center to define the polarization profile precisely.
- Thicker Carbon target to be used to gain statistics at the edge.
- Thicker target is preferable in terms of durableness.

Dedicated Polarization Measurements in Run5 (Yellow)





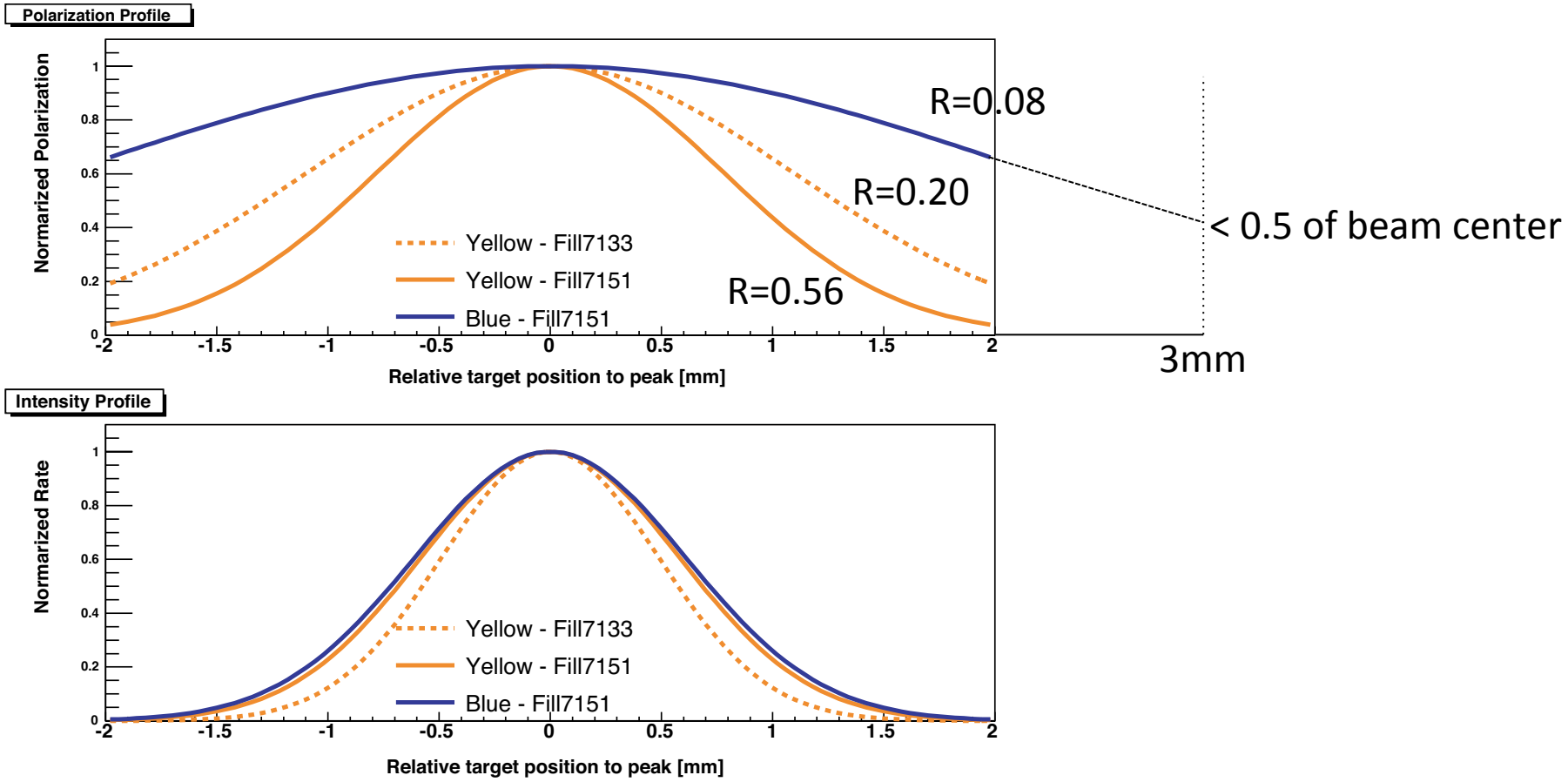




R=0.20

R=0.56

Expected polarization at 3mm away from the center



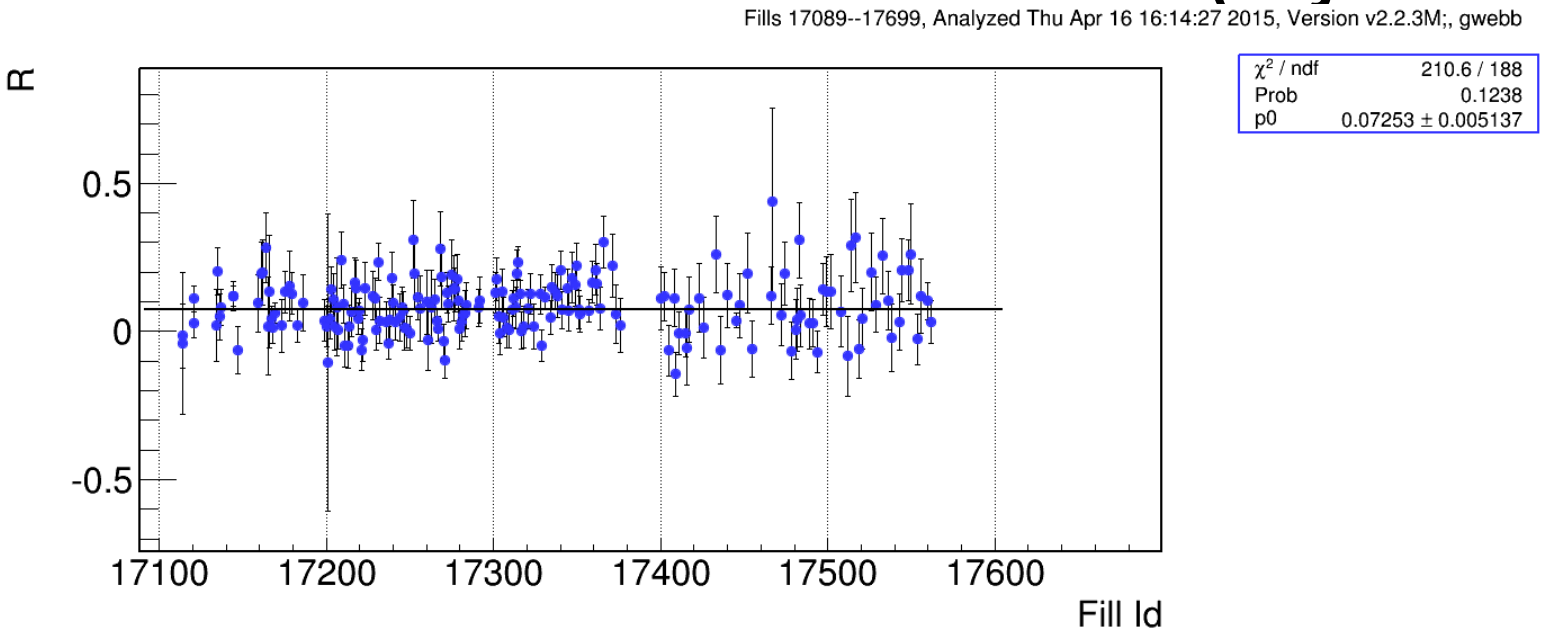
The expected polarization will be about a half at 3mm away from the beam center for R=0.08. The polarization for R>0.20 will be almost zero.

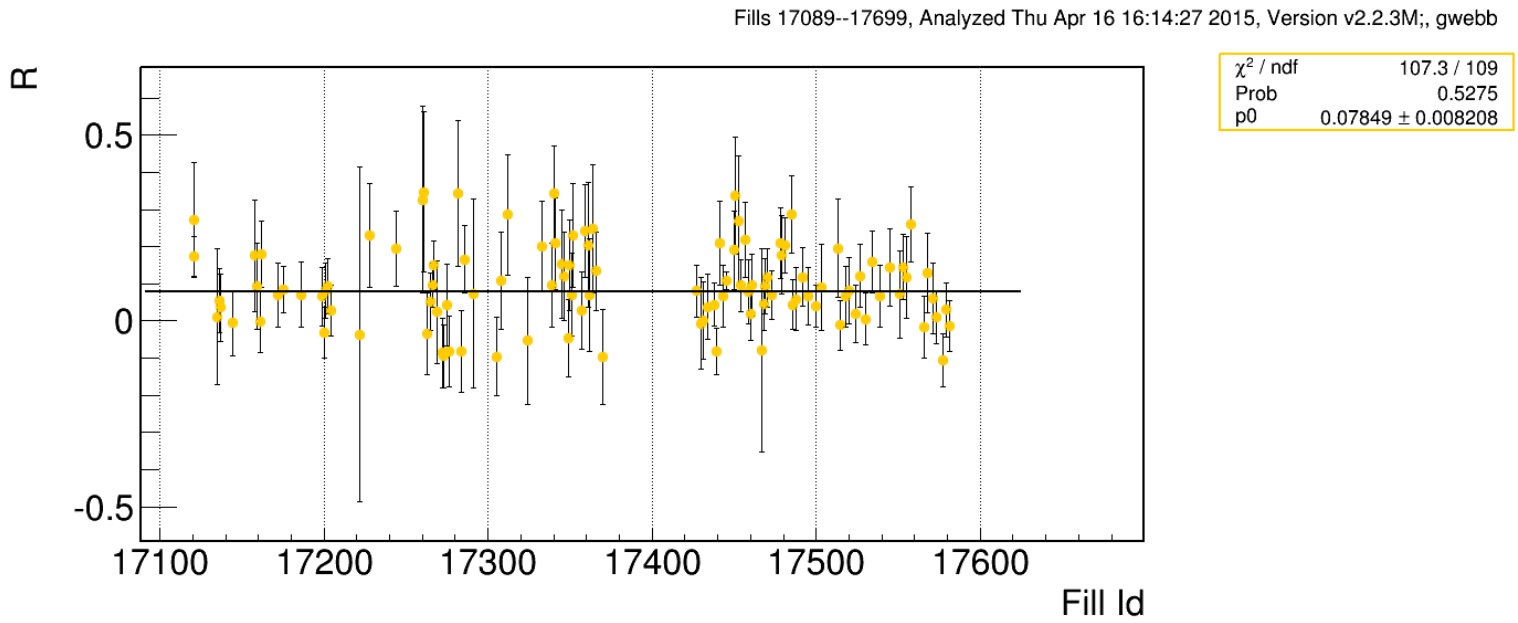
Run9 Profile Summary

Table 2
The polarization profile parameter R, average over fills . For the "low rate" case data was used with rates < 30 kHz/strip (notice, only few points satisfied "low rate" condition at $\sqrt{s} = 500$ GeV (see Fig. 31), so the corresponding numbers can not represent the average R from the whole data sample).

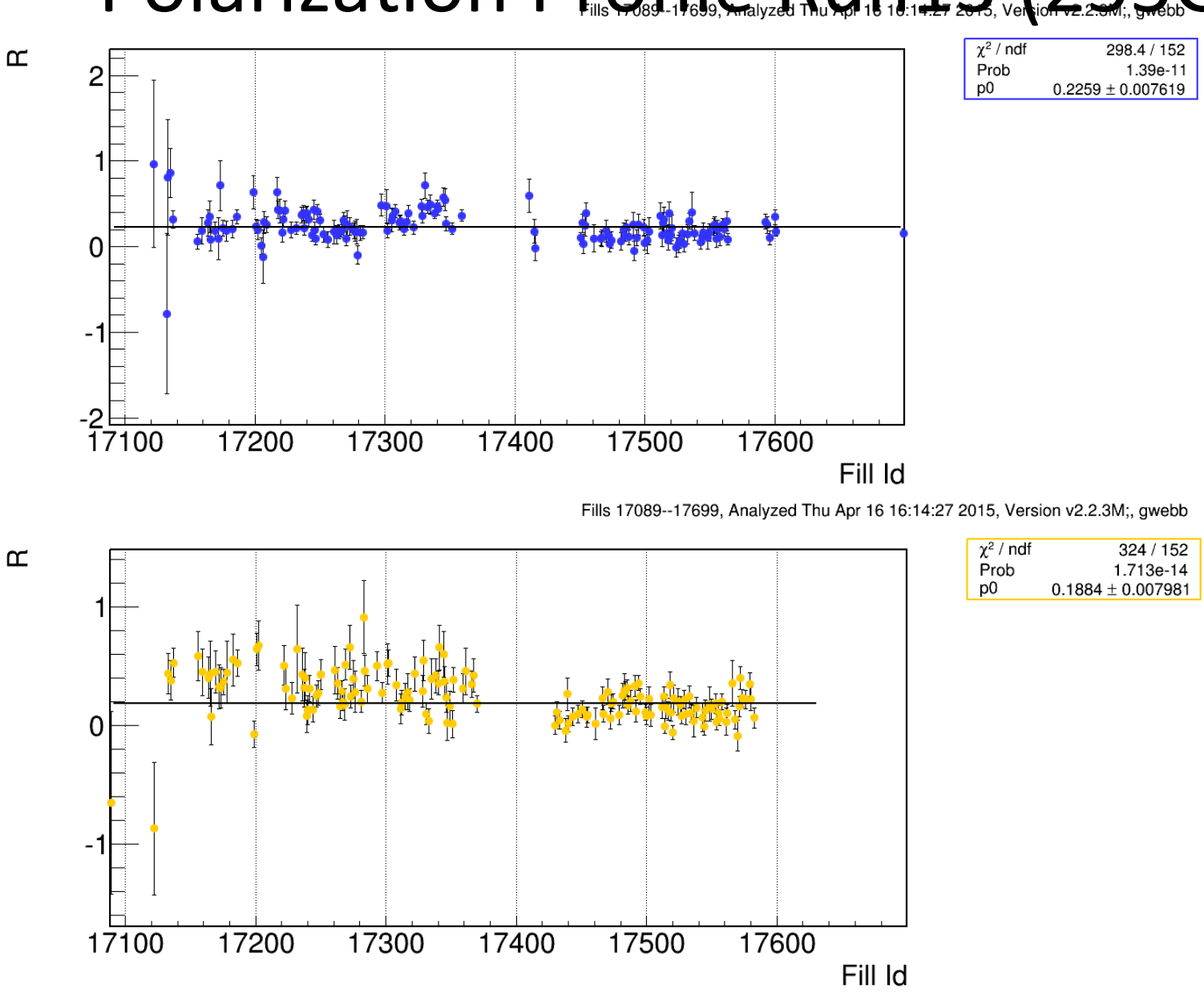
$\sqrt{s}, GeV$	Blue-Horiz	Blue-Vert	Yell-Horiz	Yell-Vert
500, from Fig. 31 (all)	0.29 ± 0.02	0.22 ± 0.02	0.31 ± 0.02	0.27 ± 0.02
500, from Fig. 31 (low rate)	0.63 ± 0.09	0.49 ± 0.10	0.31 ± 0.07	0.41 ± 0.08
500, from Fig. 35 (good prof)	0.37 ± 0.04	—	0.32 ± 0.03	0.39 ± 0.03
200, from Fig. 32 (all)	0.053 ± 0.005	0.050 ± 0.010	0.067 ± 0.005	0.066 ± 0.006
200, from Fig. 32 (low rate)	0.061 ± 0.011	0.076 ± 0.015	0.076 ± 0.015	0.089 ± 0.014
200, from Fig. 36 (good prof)	0.073 ± 0.012	0.075 ± 0.015	0.056 ± 0.010	0.117 ± 0.018

Polarization Profile Run13 (injection)

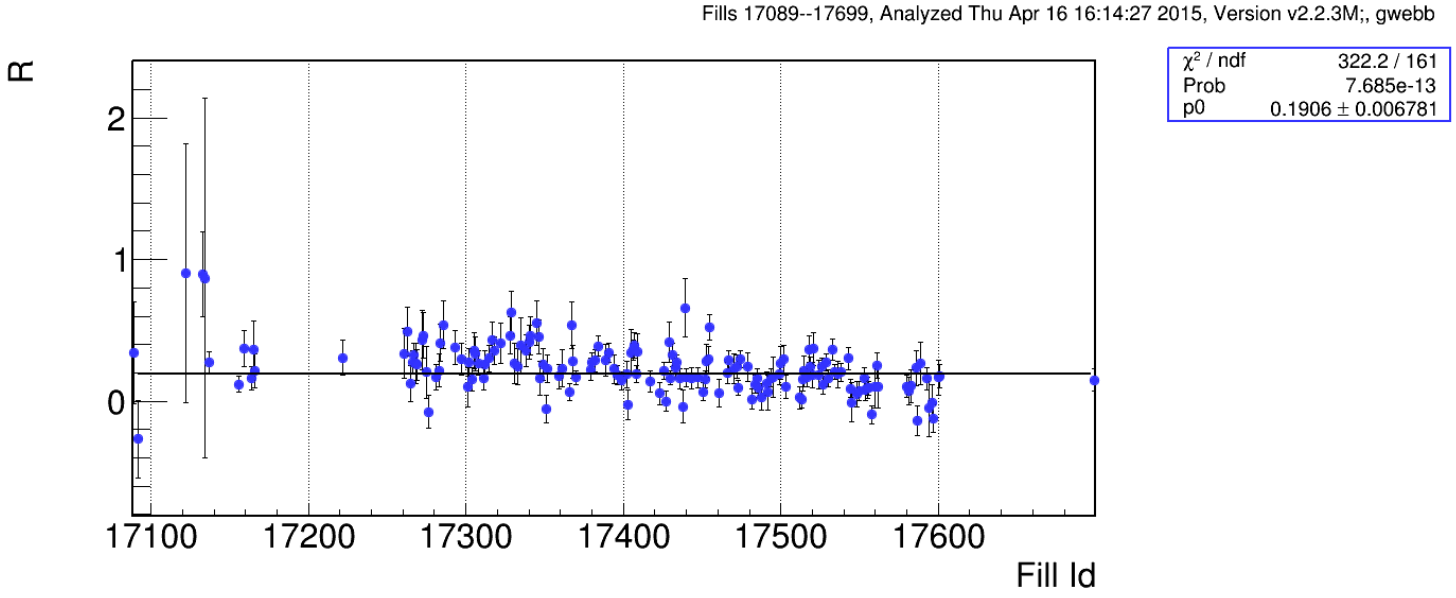


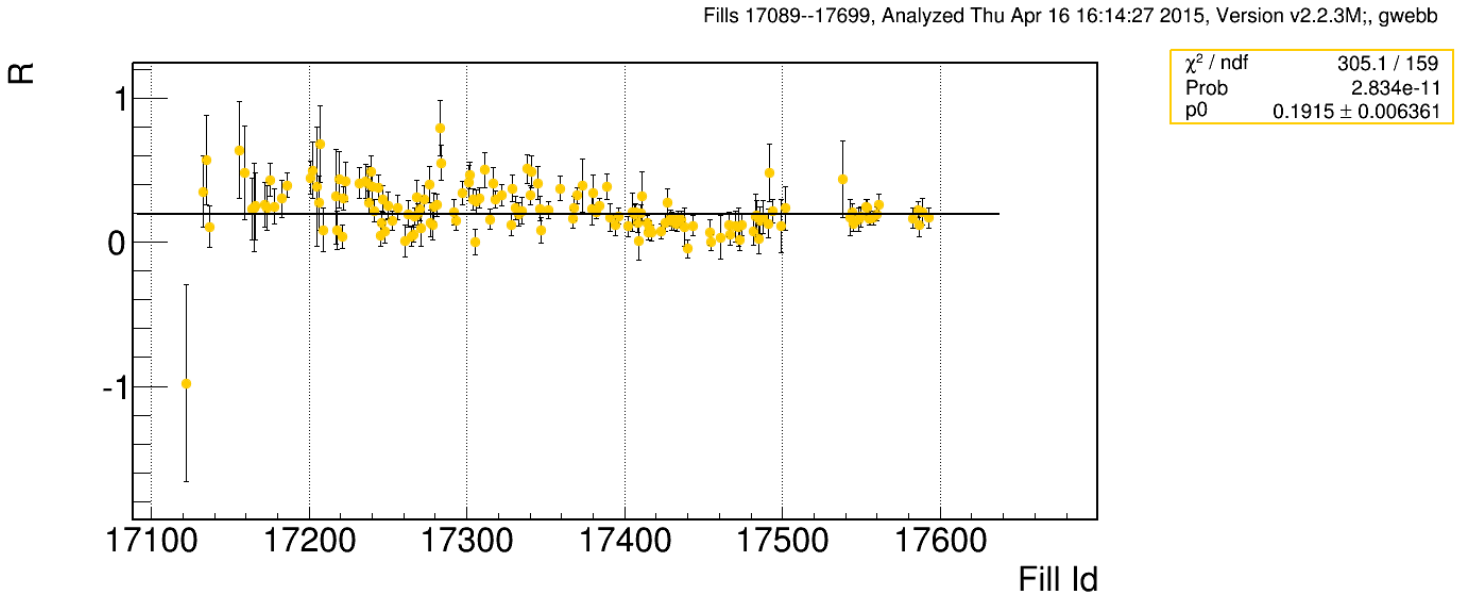


Polarization Profile Run13 (255GeV)



Polarization Profile Run13 (255GeV)





Polarization Profile Run12 (100GeV)